इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”
Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

“पुराने को छोड नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

IS 13666 (1993): Energy storage capacitors [ETD 29: Power Capacitors]

“ज्ञान से एक नये भारत का निर्माण”
Satyanarayan Gangaram Pitroda
“Invent a New India Using Knowledge”

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”
Bhartṛhari—Nītiśatakam
“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE

BRUTUM FULMEN

IGNORANTIA JURIS NON EXCUSAT

PROTECTED BY COPYRIGHT

IS 13666 : 1993

(Reaffirmed 2004)

भारतीय मानक

ऊर्जा भंडारण के लिये संधारित्रों — विशिष्ट

Indian Standard

ENERGY STORAGE CAPACITORS — SPECIFICATION

UDC 621·319·4·016·4

© BIS 1993

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

May 1993 **Price Group 4**

Power Capacitors Sectional Committee, ET 29

CONTENTS

	Page
1 SCOPE	1
2 REFERENCES	1
3 TERMINOLOGY	1
4 CATEGORIES	2
5 RATING	2
6 OVERLOAD	2
7 SAFETY REQUIREMENTS	3
8 EARTHING	3
9 MARKING	3
10 CLASSIFICATION OF TESTS	3
11 VISUAL EXAMINATION	4
12 MEASUREMENT OF CAPACITANCE	4
13 VOLTAGE TEST BETWEEN TERMINALS	4
14 VOLTAGE TEST BETWEEN TERMINALS AND CONTAINER	4
15 MEASUREMENT OF DISSIPATION FACTOR	4
16 MEASUREMENT OF EQUIVALENT SERIES IMPEDANCE	4
17 MEASUREMENT OF EQUIVALENT SERIES RESISTANCE	5
18 CAPACITOR DISCHARGE TEST	6
19 DC LIFE TEST	6
20 LIFE EXPECTANCY/ENDURANCE TEST	6
21 INSULATION RESISTANCE TEST	6
22 SEALING TEST	7
23 CHARGE/DISCHARGE CYCLE TEST	7
ANNEX A	8

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Power Capacitors Sectional Committee had been approved by the Eletrotechnical Division Council.

This standard is intended to provide guidance on the requirements and methods of checking the energy storage capacitors used in power electronics and research application.

The requirements of power electronic capacitors for filters are covered in IS 13648 : 1992.

Energy storage capacitors must be suitable so that they can be charged to their rated voltage and be discharged as agreed by the customer and the manufacturer.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ENERGY STORAGE CAPACITORS — SPECIFICATION

1 SCOPE

1.1 This standard covers tests and requirements for fixed capacitors designed essentially for DC with rated voltage up to 150 kVdc, using dielectric of plastic film and/or impregnated paper and electrodes of aluminium foil intended for use in energy storage and discharge.

1.2 The dimensional requirements of energy storage capacitors are not included in this standard.

2 REFERENCES

The standards given below are necessary adjuncts to this standard.

IS No.	*Title*
2500 (Part 1) : 1973	Sampling inspection tables : Part 1 Inspection by attributes and by count of defects (*first revision*)
13648 : 1992	Power electronics capacitors

3 TERMINOLOGY

3.1 The following definitions in addition to those defined in IS 13648 : 1992 shall apply.

3.1.1 *Rated Capacitance (C)*

The value of the capacitance marked on the capacitor.

3.1.2 *Rated Voltage (U_R)*

The value of the peak voltage to which the capacitor can be charged for rated life expectancy

3.1.3 *Energy of the Capacitor*

The value of the energy (in joules) which can be stored in the capacitor calculated as follows:

$$\frac{1}{2} C \times U^2_R$$

where

C is in microfarad

U_R is in volts

3.1.4 *Repetition Rate/Duty Cycle*

The frequency with which the capacitor can be charged and discharged at rated voltage and at rated peak discharge current. This is expressed in terms of pulse per minute (PPM) or pulse per second (PPS).

3.1.5 *Percentage Voltage Reversal*

The maximum reversed voltage which can be impressed across the capacitor expressed in percentage of rated voltage (U_R).

3.1.6 *Peak Discharge Current*

The maximum value of the current that can be discharged through the capacitor.

3.1.7 *Equivalent Series Inductance (ESL)*

The internal series equivalent inductance of the capacitor.

3.1.8 *Equivalent Series Resistance (ESR)*

The internal series equivalent resistance of the capacitor.

3.1.9 *Life Expectancy*

The number of charge and discharge cycles for which the capacitor is designed.

3.1.10 *Charging Time*

The specified time in which the capacitor is charged to its full rated voltage starting from zero (*see* Fig. 1).

3.1.11 *Discharging Time*

The specified time in which the capacitor discharges from peak value to zero (*see* Fig. 1).

3.1.12 *Hold Time*

The specified time for which the capacitor holds the charge before starting to discharge (*see* Fig. 1).

3.1.13 *Ringing Frequency*

The natural resonance frequency expressed in Hz of a capacitor due to its own capacitance and self inductance (*see* Fig. 1).

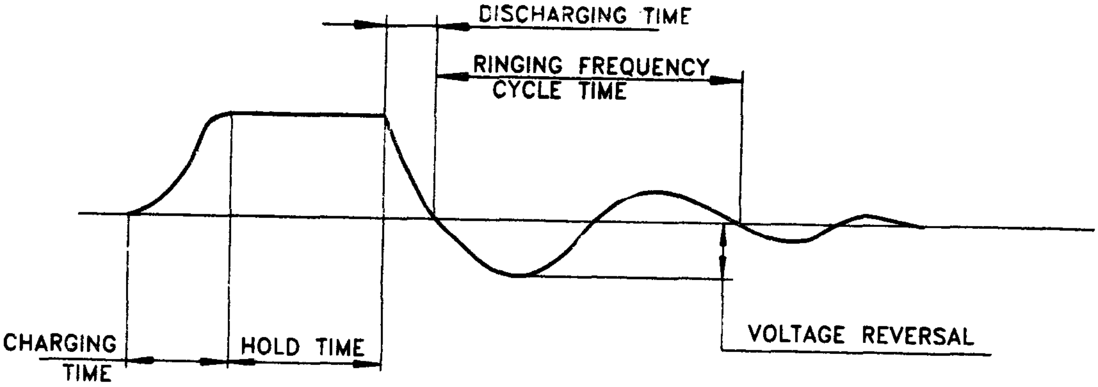


FIG. 1 VOLTAGE WAVEFORM PARAMETERS

3.1.14 *Tangent Loss Angle*

Tangent of ratio of internal resistance to reactance of the capacitor.

3.1.15 *Crow Barring*

Shorting the output of the capacitor effectively at any point on the self oscillating cycle of a capacitor in discharge.

3.1.16 *Total dc Life*

Cumulative period in hours over which a capacitor can be charged at full voltage and held there under charged conditions.

3.1.17 *Cooling Air Temperature*

The temperature of the cooling air measured at the hottest position in the bank, midway between two units. If only one unit is involved, it is the temperature measured at a point approximately 30 cm away from the capacitor container and at two-thirds the height from its base.

3.1.18 *Container Temperature-Rise*

The difference between the temperature of the hottest point of the container and the temperature of the cooling air.

4 CATEGORIES

4.0 Energy storage capacitors are classified into different categories depending on maximum peak current, repetition rate, working temperature, storage temperature, or inductance value.

4.1 Classification Based on Maximum Peak Current

Category A1	Maximum peak current	25 kA
Category A2	Maximum peak current	50 kA
Category A3	Maximum peak current	200 kA
Category A4	Maximum peak current	500 kA

4.2 Classification Based on Repetition Rate

Category A	Up to	5 PPM
Category B	Up to	1 PPS
Category C	Up to	10 PPS
Category D	Up to	100 PPS
Category E	Over	100 PPS

4.3 Classification Based on Temperature

Category L	0 to 45°C ambient
Category H	0 to 50°C ambient

4.3.1 Classification Based on Storage Temperature

Category L1	0 to 70°C
Category H1	0 to 50°C

4.4 Classification Based on Inductance Value

Category 1	15 to 60 nanohenry
Category 2	61 to 150 nanohenry
Category 3	above 150 nanohenry

5 RATING

5.1 Rated Percentage Voltage Reversal

The preferred values of percentage voltage reversals are 20 percent to 80 percent.

6 OVERLOAD

The maximum permissible overload current shall be 1·1 times the rated peak discharge current at rated percentage voltage reversal and rated voltage,

where

$I\ (\text{peak}) = K \times U_R \times \left(\frac{C}{L}\right)^{0.5}$ and K is a constant depending on percentage voltage reversal.

NOTE — Overload current is not same as fault current.

7 SAFETY REQUIREMENTS

7.1 As external/internal discharge devices are not employed, a warning "DISCHARGE CAPACITOR BEFORE HANDLING" should be prominently marked in RED on the capacitor body.

7.2 The output terminals of the capacitor shall be kept permanently shorted with a crow bar, when not in service.

7.3 Where large capacitor banks are installed, it is advisable to surround the banks with protective walls or padlockable earthed metallic gates.

8 EARTHING

If the metal container of a capacitor is at earth potential in normal service, provision shall be made to connect it to earth in a reliable way and with an adequate size of conductor and shall be clearly marked with EARTH symbol.

9 MARKING

9.1 The capacitor shall be provided with a rating plate with the following markings;

a) Manufacturer's name or trade-mark,
b) Reference to this standard, that is, Ref IS......;
c) Manufacturer's identification number;
d) Rated output in µf/pf;
e) Rated voltage in kV dc;
f) Rated energy in kJ;
g) Peak discharge current in kA;
h) Percentage voltage reversal;
j) Repetition rate in PPM or PPS;
k) Total weight;
m) Type of dielectric/impregnant;
n) Inductance ESL in nH;
p) Indication of category according to this standard; and
q) Upper limit of temperature category.

NOTE — For small unit where it is not practical to accommodate all the above information on the name plate, the information shall be provided in a separate instruction sheet and the rating plate shall bear a reference to this instruction sheet.

9.2 The energy storage capacitors may also be marked with the Standard Mark.

10 CLASSIFICATION OF TESTS

10.0 General

Unless otherwise specified, the ambient temperature range for testing shall be 10°C to 40°C. If any correction is to be applied, then the reference temperature shall be 27°C ±2°C.

The temperature of the dielectric of the capacitor unit may be assumed equal to ambient temperature provided the capacitor has been left in un-energized state at a constant temperature for an adequate period.

10.1 Type Tests

The following shall constitute the type tests and shall be carried out in the sequence given below, as far as possible:

a) Test for capacitance (*see* **12**),
b) Voltage test between terminals (*see* **13**),
c) Voltage test between terminals and container (*see* **14**),
d) Measurement of dissipation factor (*see* **15**),
e) Measurement of ESL (*see* **16**),
f) Measurement of ESR (*see* **17**),
g) Capacitor discharge test (*see* **18**),
h) dc life test (*see* **19**), and
j) Life expectancy/endurance test (*see* **20**).

NOTES

1 For identical designs with a given voltage rating, percentage voltage reversal and ringing frequency, life expectancy test may be carried out only on one capacitor of a suitable capacitance value. Other capacitance values shall be deemed to have passed the test.

2 If the life expectancy test is carried out at a higher percentage voltage reversal, it need not be repeated for lower percentage voltage reversals.

10.1.1 *Criteria for Approval*

Samples shall be submitted for testing alongwith the relevant testing data. The testing authorities shall issue a type approval certificate if the capacitors are found to comply with the requirements of **10.1**.

10.2 Routine Tests

The following shall constitute the routine test:

a) Visual examination (*see* **11**),
b) Sealing test (*see* **22**),
c) Test for capacitance (*see* **12**),
d) Insulation resistance test (*see* **21**),
e) Voltage test between terminals (*see* **13**),
f) Voltage test between terminals and container (*see* **14**),
g) Measurement of dissipation factor (*see* **15**), and
h) Charge/discharge cycle test (*see* **23**).

10.3 Acceptance Tests

The following shall constitute the acceptance tests:

a) Visual examination (*see* **11**),
b) Sealing test (*see* **22**),
c) Test for capacitance (*see* **12**),
d) Insulation resistance test (*see* **21**),
e) Voltage test between terminals (*see* **13**),
f) Voltage test between terminals and container (*see* **14**),
g) Measurement of dissipation factor (*see* **15**), and
h) Charge/discharge cycle test (*see* **23**).

10.3.1 Unless otherwise specified, the sampling procedure given in Annex A shall be followed for carrying out acceptance tests specified in the standard.

11 VISUAL EXAMINATION

All capacitors shall be examined for finish, dimensions and markings.

12 MEASUREMENT OF CAPACITANCE

12.1 The capacitance shall be measured using either of the two methods given in **12.1.1** and **12.1.2**.

12.1.1 *Schering Bridge Method*

The capacitance value shall be measured with a Schering bridge at bridge frequency of 1 kHz at room temperature. The value measured shall be within ±10 percent of the rated value.

12.1.2 *50 Hz Bridge Method*

The capacitance value shall be measured by a suitable bridge at 50 Hz and at suitable voltage depending on capacitance value. The value measured shall be within ±10 percent of the rated value.

12.2 The measuring method shall be such that the error does not exceed:

a) ten percent of the rated capacitance tolerance for absolute capacitance measurements, and

b) ten percent of the specified maximum change of capacitance for measurements of variation of capacitance.

12.3 The capacitance value shall correspond with the rated capacitance taking into account the rated tolerance or any other limit laid down in the relevant test in this standard.

13 VOLTAGE TEST BETWEEN TERMINALS

A dc voltage equal to 1·1 times the rated voltage shall be applied for a period of 1 minute between terminals of the capacitors. The voltage may be applied initially not more than 50 percent of the full value and then may be raised gradually to the full value. There shall be no breakdown of the dielectric material.

NOTE — Repeated applications of high voltage may be done at 80 percent of the test voltage.

14 VOLTAGE TEST BETWEEN TERMINALS AND CONTAINER

14.1 A dc voltage equal to 1·1 times the sum of rated voltage and reversal voltage shall be applied for one minute between the terminals shorted together and the body. However, the minimum test voltage shall be 3 kV dc. The voltage shall be applied suddenly. The capacitor shall be discharged fully before and after this test.

There shall be no breakdown of the insulation between terminals and the body of the capacitor.

14.2 This test may be eliminated when there is only one live terminal and/or the container is of plastic/insulating material.

15 MEASUREMENT OF DISSIPATION FACTOR

Measurement of dissipation factor shall be carried out with low voltage Schering bridge at bridge frequency of 120 Hz.

Depending upon the type of insulating material used, the maximum value of DF shall be agreed upon between the customer and the manufacturer. The values shall, however, not exceed those specified below:

	Dielectric	*Max Value of DF*
1	Paper/Castor oil	0·005
2	Dielectric other than above	As agreed between the purchaser and the manufacturer

16 MEASUREMENT OF EQUIVALENT SERIES IMPEDANCE

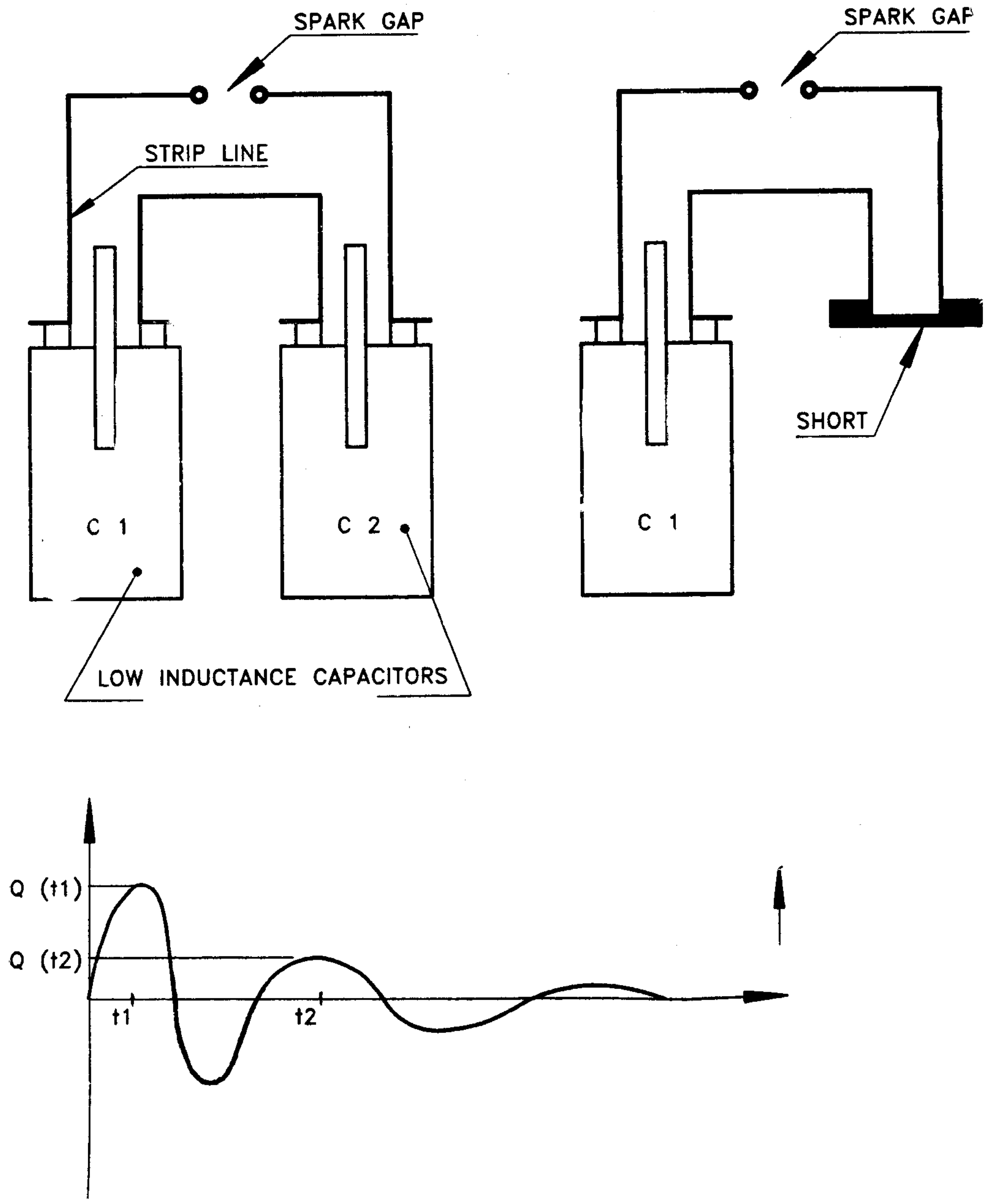
Two identical capacitors shall be connected in series with a spark gap as shown in Fig. 2. The test voltage shall not be greater than 2 kV dc. Care shall be taken so as not to exceed the peak discharge current rating.

The value of ESL determined as above shall be in accordance with requirement of the purchaser.

17 MEASUREMENT OF EQUIVALENT SERIES RESISTANCE

ESR measurement shall be carried out on two identical capacitors as shown in Fig. 2.

The value of ESR determined as above shall be in accordance with the requirement of the purchaser.



(1) TOTAL CIRCUIT INDUCTANCE

$$L_T = \frac{C_1 + C_2}{W^2 C_1 \times C_2}$$

(2) TOTAL CIRCUIT RESISTANCE

$$R_T = \frac{2L_T \, Ln \frac{Q(t_1)}{Q(t_2)}}{t_2 - t_1}$$

FIG. 2 DIFFERENTIAL CAPACITOR MEASUREMENT

18 CAPACITOR DISCHARGE TEST

The capacitor shall be charged by means of dc to its rated voltage and discharge without a reactor through a gap situated as close as possible to the capacitor. It shall be subjected to five such discharges within 10 minutes.

Five minutes after this test, the unit shall be subjected to a voltage test as specified in **13**. The capacitance shall be measured at ambient temperature before the capacitor discharge test and after the voltage test. The change in ambient temperature shall not be more than ± 2°C. The change of capacitance shall not exceed 2 percent.

19 DC LIFE TEST

The capacitor shall be brought to the specified ambient temperature inside a cabinet. It shall be charged to its rated voltage and held at this voltage continuously through a trickle charge within ±5 percent variation. The test is continued till there is a breakdown. The time to breakdown shall be taken as the total dc life.

20 LIFE EXPECTANCY/ENDURANCE TEST

The capacitor shall be housed in an enclosure and brought to the specified ambient temperature before and during this test. The charging time, peak charged voltage, the voltage reversal on first cycle and the rated discharge current shall be obtained.

Through an automatic switching device, the charging/discharging cycle shall be maintained at the specified repetition rate or a quicker rate as agreed upon.

The peak voltage may be measured directly across the charging source, during the cycle.

The peak current may be measured through a current shunt or a calibrated Rogoski Coil across a long persistant oscilloscope. The voltage reversal may be measured across the same oscilloscope.

The rated life of the capacitor varies between 10^4 to 10^6 cycles. The number of cycles to be tested may be agreed between the testing authority and the manufacturer, alternatively accelerated life test may be agreed.

If the testing set-up, including electric supply, fails, the test may be continued after restoration of the same and due credit may be given for the number of cycles already covered as the dielectric degradation due to thermo-electric effects is expected to be of a non-reversing character.

The sample shall pass the test if there is no appreciable change in the values of capacitance and dissipation factor measured under the same conditions before the test.

21 INSULATION RESISTANCE TEST

21.1 Measurement of insulatson resistance shall be made

a) between terminals (*see* **21.2**), and

b) between terminals shorted and case, if the case is not one of the terminals (*see* **21.3**).

21.2 Insulation Resistance Test Between Terminals

21.2.1 The test voltage shall be 10 kV dc for capacitors rated at 10 kV dc or above, and 1 kV dc for capacitors rated between 1 kV to 10 kV. The test voltage shall be applied through internal resistance of the test apparatus.

21.2.2 After charging the capacitor shall be left open for a period of 5 minutes ± 5 sec.

21.2.3 At the end of 5 minutes, residual voltage left on the capacitor shall be measured with a voltmeter with suitable impedance and sufficient accuracy.

21.2.4 Insulation resistance (R) between terminals shall be computed from the following formula:

$$R = \frac{t}{2{\cdot}3 \times C \times \log (V_1/V_2)}$$

where

t = time in sec,

C = capacitance in μf,

V_1 = test voltage,

V_2 = residual voltage, and

R = insulation resistance in megaohm.

21.2.5 The insulation resistance value of capacitors shall not be less than 1 000 Ohm-farad at reference temperature of 25°C.

21.2.6 If the test temperature is different than 25°C, appropriate correction factor shall be applied to determine actual insulation resistance.

21.2.7 Figure 3 gives the circuit arrangement for the insulation resistance test.

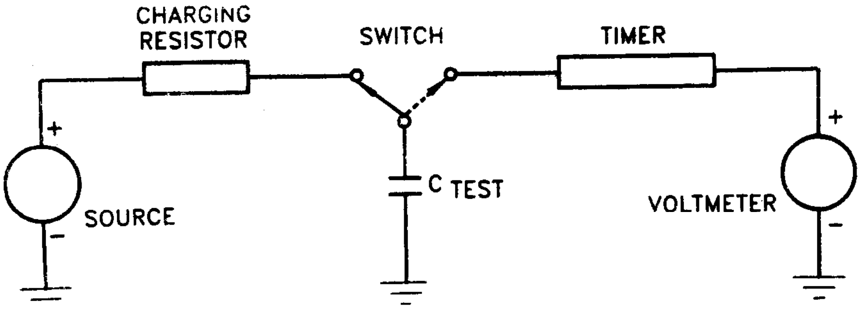


FIG. 3 I. R. TEST

21.3 Insulation Resistance Test Between Terminals and Container

Every capacitor shall be subjected to an insulation resistance test between terminals and container, except when one terminal of the capacitor is connected to the container or when the container is made of plastic/insulating material. The test voltage shall be 3 kV dc or rated voltage whichever is less. The ripple content in the test voltage shall not be more than 10 percent. The insulation resistance shall not be less than 50 megaohms.

22 SEALING TEST

For capacitors having a rated voltage up to and including 650 V, the test shall be carried out at 80 ± 5°C for a period of 3 hours. For capacitors having a rated voltage above 650 V, the test shall be carried out at 70 ± 5°C for a period of 12 hours.

23 CHARGE/DISCHARGE CYCLE TEST

23.1 The test shall be carried out as per the procedure and sequence indicated below:

a) The test circuit shall be as per Fig. 4.

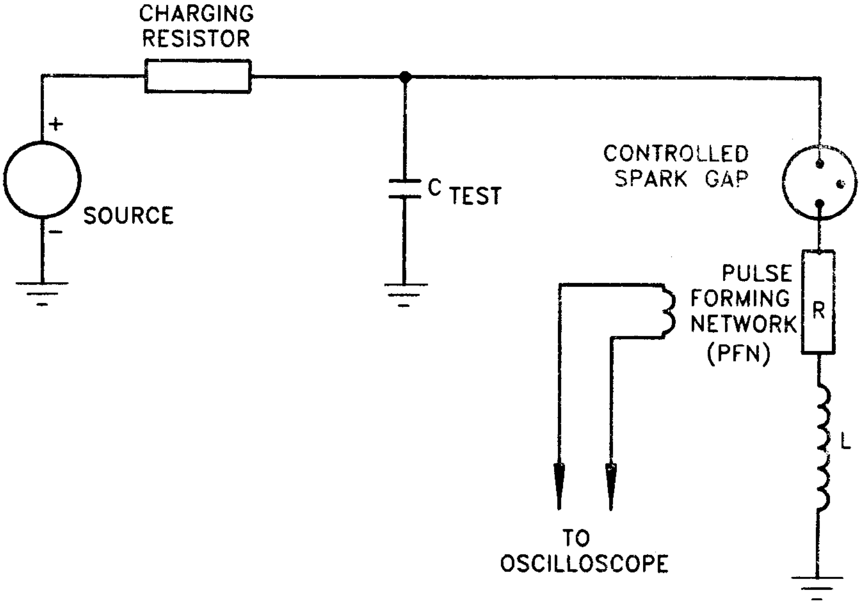


FIG. 4 CHARGE DISCHARGE CYCLE TEST

b) The capacitance and dissipation factor value shall be measured (*see* **12** and **15**).

c) The capacitor shall be charged at rated voltage.

d) The capacitor shall be discharged through a controlled spark gap or other appropriate device and through pulse forming network such that rated peak discharge current flows through the circuit. The current shall be monitored on a long persistant or a storage oscilloscope.

e) The above charging and discharging shall be repeated as per PPM/PPS rating and for 100 cycles through appropriate arrangement.

f) After completion of above cycles, capacitance and dissipation factor values shall be measured under same conditions as in (b).

23.2 The capacitor shall pass the test if the change in capacitance value is not greater than 2 percent and the change in dissipation factor value is not greater than 0·001.

ANNEX A

(*Clause* 10.3.1)

SAMPLING PLAN FOR ACCEPTANCE TESTS

A-1 LOT

In a consignment all the capacitors of the same rating manufactured from the same material under similar conditions of production shall be grouped together to constitute a lot.

A-2 Unless otherwise agreed to between the supplier and the purchaser, the procedure given in IS 2500 (Part 1) : 1973 shall be followed for sampling inspection. For all the acceptance tests, single sampling plan with inspection level IV and an AQL of 2·5 percent as given in Tables 1 and 2 of IS 2500 (Part 1) : 1973 shall be followed.

Standard Mark

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attenting to connected matters in the country.

Copyright

BIS has copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Revision of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards Monthly Additions'. Comments on this Indian Standard may be sent BIS giving the following reference:

Doc : No. ET 29 (3262)

Aendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:
Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 11002

Telephones : 331 01 31, 331 13 75

Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices :	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 11002	331 01 31 331 13 75
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola CALCUTTA 700054	37 84 99, 37 85 61 37 86 26, 37 86 62
Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036	53 38 43, 53 16 40 53 23 84
Southern : C. I. T. Campus, IV Cross Road, MADRAS 600113	235 02 16, 235 04 42 235 15 19, 235 23 15
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) BOMBAY 400093	632 92 95, 632 78 51 632 78 91, 632 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. PATNA. THIRUVANANTHAPURAM.

Printed at Printwell Printers, Aligarh, India